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Movements of Tagged Summer Flounder, *Paralichthys dentatus*, off Southern New England

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U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

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Movements of Tagged Summer Flounder, *Paralichthys dentatus,* off Southern New England

F. E. LUX and F. E. NICHY[1]

ABSTRACT

A total of 2,839 summer flounder were tagged on outer continental shelf and coastal grounds off southern New England in 1961-62. Tag recaptures showed the migration to offshore grounds in fall and winter and to inshore areas in spring and summer. Recaptures from coastal grounds were recorded from northern New Jersey to south of Cape Cod; those from outer shelf grounds were from Baltimore Canyon on the southwest to Veatch Canyon on the northeast. The overall tag return rate was 21.2%; however, the returns from inshore tagging (44.5%) were much higher than those from offshore releases (8.4%), suggesting that tagging mortality was higher offshore.

INTRODUCTION

Adults of summer flounder, *Paralichthys dentatus,* are found in Atlantic coastal waters from Maine to Florida (Bigelow and Schroeder 1953; Wilk et al. 1980). They are most abundant in the Middle Atlantic Bight, the coastal concavity between Cape Cod and Cape Hatteras, where they are fished intensively (Fig. 1). From late spring to fall summer flounder are sought by recreational and commercial fishermen in coastal areas; from December to April they are fished by otter trawlers along the outer continental shelf edge. Vessels from New Jersey to Virginia fish this species in the southern part of the bight; those from New York and New England fish the areas from Long Island to south of Cape Cod.

The reported commercial catch of summer flounder in 1979 was 13,932 t, of which 3,220 t were taken within 3 mi (5.5 km) from shore and 10,712 t were from waters beyond 3 mi but within the 200-mi (370 km) conservation zone (Pileggi and Thompson 1980). The recreational catch for 1979, which we estimated from angler survey data (National Marine Fisheries Service 1980), was about 10,000 t.

Young-of-the-year summer flounder occur sporadically in bays from southern New England to New Jersey; however, the principal nursery grounds are in estuaries and bays of Virginia and North Carolina (Poole 1966). The fish apparently disperse northward as they grow older and make up the stocks that are exploited in the northern part of the bight. Fish <25 cm in length are uncommon in New York waters (Westman and Neville 1946). This also appears true of southern New England; we measured samples from commercial otter trawl catches of this species there in 1960-62 and found no fish <28 cm long in 18 trips from offshore areas and 5 from inshore areas. This was not due to discarding the smaller fish, since the entire catch of New England summer flounder is marketed. The cod end mesh sizes in the trawls for the 23 trips were mostly 114 mm or less and would have retained flounders smaller than 28 cm (Lux 1968). National Marine Fisheries Service otter trawl survey catches in 1964-79 off southern New England, using 15 mm mesh cod ends, also showed a scarcity of summer flounder <28 cm long.[2]

Marking studies off New York and New Jersey have shown the seasonal pattern of movement of this species: In the fall from coastal areas to the outer continental shelf winter grounds, and in the spring returning to the coast (Westman and Neville 1946; Poole 1962; Murawski 1970[3]). These studies also indicated that with the passage of time the tagged fish tended to be caught farther to the north within the bight.

To learn more about the seasonal and long-term movements of summer flounder off southern New England, we tagged 2,839 of these fish on both coastal and offshore grounds in 1961-62. The results of this study are reported here.

TAGGING PROCEDURE

The summer flounder for tagging were caught with otter trawls. For the offshore tagging we used the Bureau of Commercial Fisheries' RV *Delaware*. For the inshore tagging we used commerical otter trawlers. Tow length varied from 30 to 60 min. On the *Delaware* the fish were held in tanks of running seawater until tagged, whereupon they were immediately released. On the commercial vessels the fish were tagged from the net as they were brought aboard and then immediately released. Total length in millimeters, date, and tagging location were recorded for each tagged fish. All of the summer flounder caught were tagged, except for the small number, of various sizes, whose physical appearance indicated that they were moribund. Therefore the tagged population was considered representative of the catch.

The seasons for tagging were chosen to minimize loss of tagged fish to fishing before they had moved from release areas. Thus, the 1961 offshore tagging was done in early April, which

[1]Northeast Fisheries Center Woods Hole Laboratory, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

[2]Sissenwine, M. P., R. R. Lewis, and R. K. Mayo. 1979. The spatial and seasonal distribution of summer flounder (*Paralichthys dentatus*) based on research vessel bottom trawl surveys. Northeast Fisheries Center, National Marine Fisheries Service, Woods Hole, Mass. Lab. Ref. No. 79-55, 9 p.

[3]Murawski, W. 1970. Results of tagging experiments of summer flounder, *Paralichthys dentatus,* conducted in New Jersey waters from 1960-67. N.J. Dep. Environ. Prot., Misc. Rep. 5M, 45 p. (N.J. Division of Fish, Game and Shellfisheries, Box 1809, Trenton, N.J. 08625.)

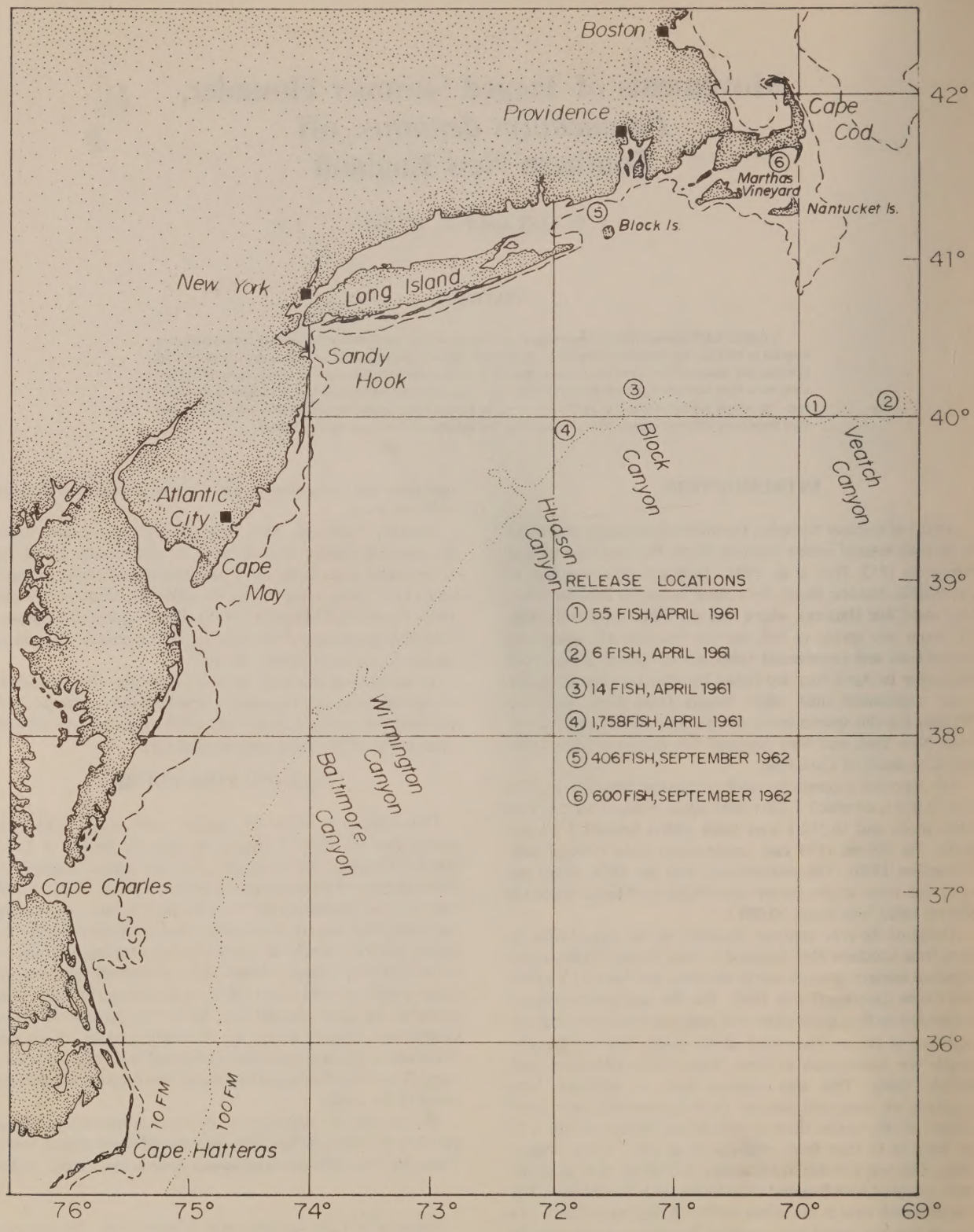

Figure 1.—Map of the Middle Atlantic Bight showing locations where summer flounder were tagged and released in 1961 and 1962.

is near the end of the winter fishery, and the 1962 inshore tagging was done in September, near the end of the summer fishery.

Fish just tagged were sometimes caught in subsequent tagging tows. If these fish appeared lively, they were re-released and records were made of the fact.

The mesh in the cod ends of trawls used to catch the fish for tagging had a stretched measure of about 90 mm. This mesh retains flounders down to 20 cm or so in length (Clark et al. 1958; Lux 1968). We caught no summer flounder smaller than 31 cm, and we, therefore, assume that the entire size range of fish was sampled in relation to its abundance and that none escaped through the meshes.

Each tag consisted of two plastic Peterson disks, 13 mm diameter, joined by a stainless steel pin passing through the dorsum of the fish. One disk was printed with return instructions; the other carried a serial number.

A reward of $1.00 was paid for a returned tag alone, and $2.00 for a tag with the fish. Bureau of Commercial Fisheries port samplers, who were stationed in ports of landing, received most of the tags and fish returned by commercial fishermen. Sex and length of returned fish were recorded. Positions for recaptures by the commercial fleet usually were in the form of loran bearings and depths, which generally were accurate to within 10 km or less.

Recreational fishermen usually mailed in their recovered tags. They frequently gave the recovery position in terms of landmarks, such as an inlet, bay, or point. These positions probably were at least as accurate as those for commercial returns.

For tags discovered in fish markets or processing plants there was no information on recovery position; however, usually it was possible to identify them as commercially caught. For a few of the tags that were mailed in, no data could be obtained. Both sources of unplaced tags made up 3.8% of the total returns. While they were of no value for charting fish movements, they were useful in measuring total return rates and are included in the results presented below.

RESULTS

Offshore Tagging, April 1961

From 1 to 6 April, summer flounder were caught and tagged in depths of 80-145 m (Fig. 1). Most of the 1,833 fish tagged were from between Hudson and Block Canyons in about 90 m depth, approximate position lat. 39°55′N, long. 72°00′W (location 4, Fig. 1). Recoveries were obtained until August 1963, at which time a total of 155 had been reported, 8.4% of those released.

To compare the length distribution of recaptured fish with that of the tagged ones we used the fish lengths recorded at the time of tagging rather than those obtained at recovery. The size distributions, at tagging, of the fish released in 1961 and of those subsequently recaught (Fig. 2) show that most of the fish tagged were about 31-50 cm in length, with some over 60 cm; the mean length was 38.8 cm. The lengths, at tagging, of the recaptured fish were similar to those of the tagged ones (Fig. 2), suggesting that there was no significant differential in tagging mortality with fish size and that the size of recaptured fish was representative of the tagged population. The mean length of recaptured fish was also 38.8 cm.

All except one of the recoveries from 1961 releases were from fish released at location 4 in Figure 1; the following discussion applies to movement from this release point.

In April-June 1961 there were 67 tag recaptures, all with recapture positions noted. Of these, 37 were caught in April on offshore areas in the vicinity of tagging (Fig. 3). In addition, three late April recoveries were caught on inshore areas of Long Island. The other 27 recoveries were caught in May and June on inshore grounds, primarily from the ocean side of Long Island. One, however, was from Long Island Sound, three were from the Rhode Island shore, and two were from Vineyard Sound (just south of Cape Cod). The returns during this quarter established the time of movement from offshore to inshore grounds as April and May, at least for the area dealt with in this report, i.e., north of lat. 39°N.

There were 47 summer recoveries (July-September 1961), 46 of which had return locations noted. They were caught mostly in bays and sounds from Long Island to southern New England (Fig. 4). Many of these recoveries were from more easterly inshore areas than the spring ones, although there were also several from off western Long Island and Long Island Sound. Six returns were from as far to the east as Vineyard and Nantucket Sounds. There were no summer recoveries from south of Sandy Hook, N.J., or from east of the elbow of Cape Cod.

There were just three recoveries in the fall of 1961 (October-December), for one of which no return area was given. The other two were from south of Martha's Vineyard and Nantucket, in an area intermediate between inshore and offshore grounds, suggesting that these fish were in the process of moving offshore for the winter (Fig. 4). One of these was caught in October, the other in December.

There were 28 recoveries during January-March 1962, all of which were from offshore, and 15 of them came from the vicinity of release in the previous spring (Fig. 5). In addition, 10 others were caught well to the east of this, near Veatch Canyon, suggesting that the fish had moved eastward. The other three fish were recaught south of the release point, indicating that some southerly movement had taken place.

Of the five recaptures reported for April-June 1962, two were caught on offshore grounds in April and May and the other three were caught on Long Island inshore areas in May and June (Fig. 5). While there were few returns in this calendar quarter, the pattern of return locations was similar to that of April-June in 1961 (Fig. 3).

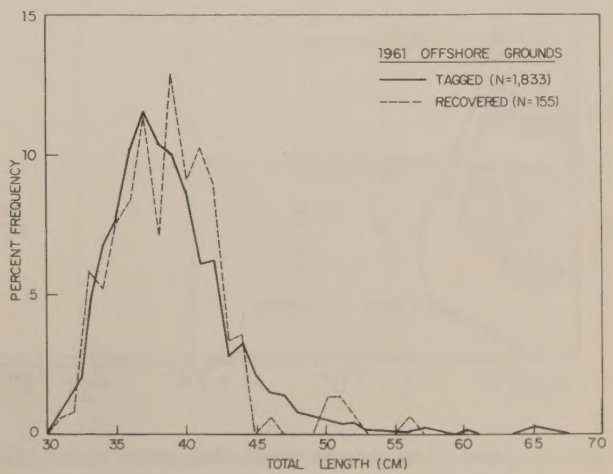

Figure 2.—Length-frequency distributions of summer flounder tagged in April 1961 on offshore grounds and of those subsequently recaptured. (All lengths are those obtained at the time of tagging.)

Figure 3.—Tagged summer flounder release positions for April 1961 releases (open squares) and recapture locations in April-June 1961 (circles).

Figure 4.—Tagged summer flounder release positions for April 1961 releases (open squares) and 1961 recapture positions in July-September (circles) and October-December (triangles).

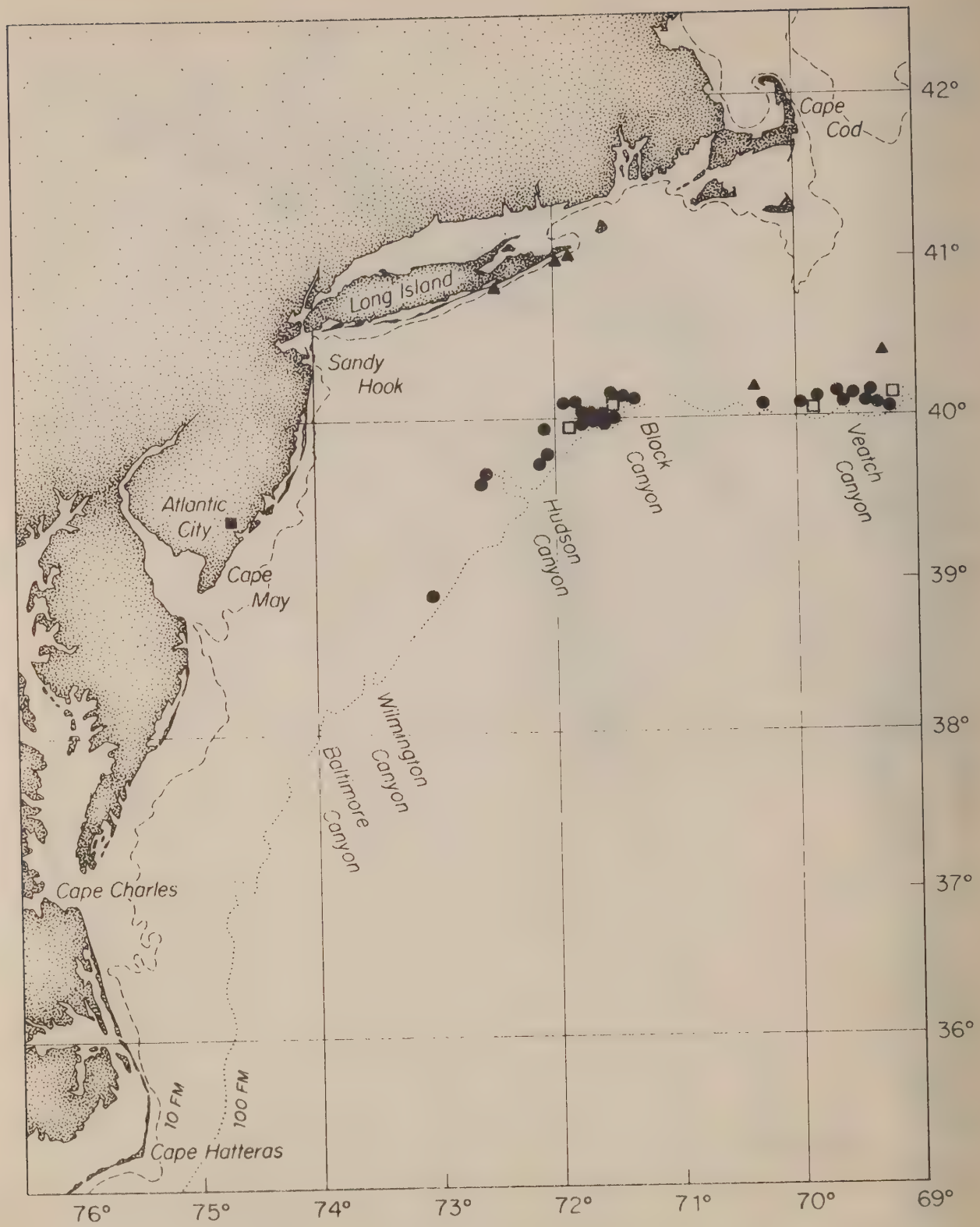

Figure 5.—Tagged summer flounder release positions for April 1961 releases (open squares) and 1962 recapture locations in January-March (circles) and April-June (triangles).

Table 1.—Recoveries of tagged summer flounder from 1961 offshore releases by season and fisherman type, April 1961-October 1963.

Period of recovery	Number of recoveries by fisherman type			
	Commercial	Recreational	Unknown	Total
1961				
April-June	60	7	—	67
July-September	13	32	2	47
October-December	2	—	1	3
1962				
January-March	28	—	—	28
April-June	3	1	—	4
July-October	2	1	—	3
1963				
May-August	3	—	—	3
All months	111	41	3	155
Percentage	71.6	26.5	1.9	100.0

Following June 1962 only six additional tags were recovered from the 1961 releases: One each in July, September, and October 1962; one in May 1963; and two in August 1963. The locations of these recoveries followed a pattern similar to that described for the 1961 recoveries in these months.

The tagged fish in the 1961 releases were caught by both commercial and recreational fishermen, with commercial gear taking 71.6% of the recoveries versus 26.5% for recreational (Table 1). While we have no exact breakdown of catch by the various commercial gears, the bulk of the recaptures were by otter trawls, and a few additional recaptures on inshore areas were by traps and seines. The recreational gear was primarily hook and line, although a few tagged fish may have been taken with spears.

Some recaptures by commercial gear were made year-round. Most, however, were caught in January-June with many of them being taken during the offshore fishery for this species in January-April (Table 1). The recoveries by recreational fishermen all were obtained during the summer months, when the fish are inshore. Most of these latter returns were caught in Long Island waters, although several also were taken off southern New England.

The length, at tagging, of the tagged fish returned by the commercial fleet ranged from 32 to 56 cm (mean = 39.3 cm). The fish returned by recreational fishermen, on the other hand, had a length range, at tagging, of 31-42 cm (mean = 37.5 cm). Thus, it appeared that fish of the recreational catch were slightly smaller in size and that considerably fewer large summer flounder were caught by anglers.

The sex of 58 of the fish released in 1961 was obtained when they were recaught and returned for measurements. The length frequencies, by sex, of these fish (at time of tagging) are presented in Figure 6. While the numbers of fish here, 22 males and 36 females, are small, there are indications of modes at about 35 cm for males and 40 cm for females.

Inshore Tagging, September 1962

The 1962 inshore tagging comprised two experiments: One in Block Island Sound and one in Nantucket Sound. The summer flounder tagged in Block Island Sound were caught and released in an area about 6 km south-southwest of Point Judith, R.I., lighthouse (approximately lat. 41°18'N, long. 71°32'W) in 18-27 m of water 6-8 September (Fig. 1). Tag recoveries from this group were obtained through March 1967. A total of 406 fish were tagged, and 203 of these were subsequently recaptured for a return rate of 50%.

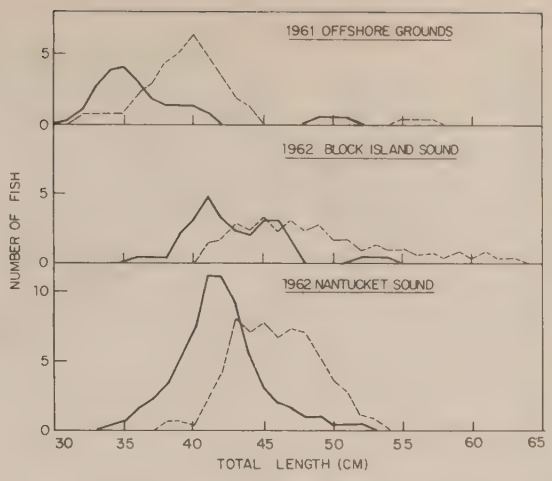

Figure 6.—Length-frequency distributions, at tagging, of male (———) and female (- - - -) summer flounder recaptures from fish tagged in 1961 on offshore grounds and in 1962 on inshore grounds.

The length distributions at time of tagging of the summer flounder released at this location and of those later recaught (Fig. 7) range from 31 to 76 cm (mean = 46.3 cm). The lengths at tagging of the recovered fish (range = 31-76 cm, mean = 46.4 cm) were similar to those of the tagged ones, indicating that the recoveries accurately represented the tagged population (Fig. 7).

The summer flounder tagged in Nantucket Sound were released in two areas off southeastern Cape Cod about 12-13 km apart: 397 fish were released 10 km south of Point Gammon (approximately lat. 41°33'N, long. 70°15'W) in 16-20 m depths 6-7 September, and 203 fish were released 6.5 km south-southwest of Monomoy Point (approximately lat. 41°32'N, long. 70°05'W) in 7-10 m depths 21 September. These areas are close together and are shown as a single position, number 6, in Figure 1. Through January 1968, when the last tag return was reported, 245 of the 600 fish tagged in these releases were recaught, a recapture rate of 40.8%.

The size distributions, at time of tagging, of all the Nantucket Sound releases and of those later recaptured (Fig. 8) show that the length range of the fish tagged here was narrow (range = 35-53 cm, mean = 43.1 cm). The lengths, at tagging, of the fish recaptured from these releases were similar (range = 35-52 cm, mean = 43.5 cm).

The patterns of tag returns for the Block Island and Nantucket Sound releases were very similar; therefore, we have combined these two groups in discussing fish movements. Charts of the tag return positions for these groups for September 1962 through December 1964, by calendar quarter, are presented in Figures 9-13.

During September 1962 (the month of tagging) 36 tag returns, all with return positions, were recorded. These were caught in the immediate vicinity of the release points (Fig. 9). In October-December 1962 the 25 returns recorded, all with return positions, showed clear evidence of fish movement to offshore wintering areas (Fig. 9), with a few tagged fish being recovered in October near the tagging sites and also on grounds intermediate between inshore and offshore areas. Two fish were recaught in October on intermediate grounds off the New Jersey coast, a straight line movement from the release point of about 335 km in just over 1 mo. In November 1962 only two tag

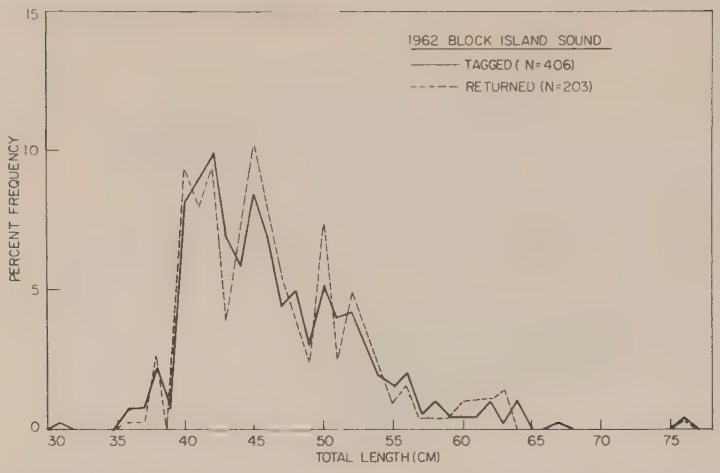

Figure 7.—Length-frequency distributions of summer flounder tagged in September 1962 in Block Island Sound and of those subsequently recaptured.(All lengths are those obtained at the time of tagging.)

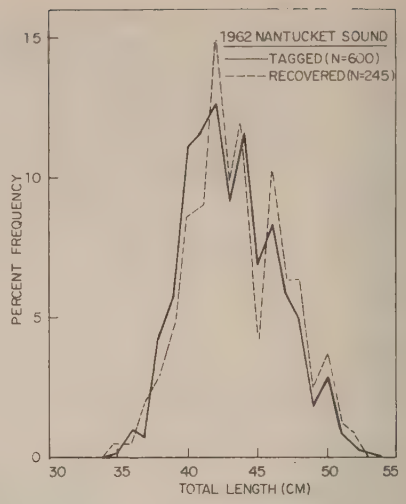

Figure 8.—Length-frequency distributions of summer flounder tagged in September 1962 in Nantucket Sound and of those subsequently recaptured. (All lengths are those obtained at the time of tagging.)

returns were reported, both from south of Nantucket. In December there were eight returns: Seven from offshore grounds and one from intermediate grounds south of Nantucket (Fig. 9).

In January-March 1963 there were 110 tag recoveries, 105 of which had return positions noted. These were caught over the outer shelf area from Veatch Canyon on the east to Baltimore Canyon on the southwest, with many recaptures coming from around Block Canyon (Fig. 10). The recaptures from these releases were spread over an area that extended considerably farther south than that recorded for recaptures from the 1961 offshore releases.

Of the 59 tag returns obtained during April-June 1963, 53 had return positions noted. These were from offshore, intermediate, and inshore grounds, showing the spring return of summer flounder to coastal areas (Fig. 10). The 17 returns in April were from offshore grounds, while the 36 caught in May and June were from coastal areas. Two of these latter were from south of Nantucket, and the rest were from more inshore points from Long Island to Nantucket Sound; none were from the New Jersey shore or from inshore areas south of there.

There were 88 tag returns in July-September 1963, of which 83 had return locations. These were from inshore areas except for one which was recovered on intermediate grounds south of the eastern end of Long Island in September (Fig. 11). The 82 inshore returns were almost entirely from waters east of Long Island, with many being caught near or at the locations of release in 1962. One, however, was caught far to the south just east of Cape May, N.J.

The 11 tag recoveries in October-December 1963, of which 8 had return locations, included 3 from inshore grounds in October, 1 from intermediat grounds in November, and 4 from offshore ground southwest of Hudson Canyon in December (Fig. 11).

The tag return locations for the 86 recoveries in 1964 (Figs. 12, 13), while fewer in number than those of 1963, reflect much the same pattern of movements as was shown then.

From January 1965 through January 1968, when the last recapture was reported, an additional 33 tags were returned from the inshore releases: 22 in 1965, 7 in 1966, 3 in 1967, and 1 in 1968. The locations of these returns, while not plotted here, followed the general seasonal migration patterns described above.

A breakdown of the tag recoveries by commercial and recreational fishermen from the inshore 1962 releases (Table 2) indicates that commercial fishermen caught about 95% of the recoveries. More than 95% of the commercial fishery returns were by otter trawl. A few were caught in traps, one in a scallop dredge. The recreational catch recaptures from these releases amounted to $<4\%$ of the total, all of which were caught by anglers. The proportion of returns caught by anglers for the Block Island Sound releases was 5.9%, compared with 1.6% for Nantucket Sound fish, suggesting that the former releases were subjected to a somewhat greater angling effort. The mean length, at tagging, of all 16 angler-caught returns in these releases was 43.6 cm. This is slightly smaller than the 44.9 cm mean length of the commercial recaptures.

All of the returns by recreational fishermen were caught from spring to fall, when the fish are close inshore (Table 2). The commercial catch was taken in all months, but few of the tagged fish were caught in October-December when they were moving offshore. The highest numbers of commercial recaptures generally were made in the January-March quarter.

The sex of 60 of the summer flounder tagged in Block Island Sound and 132 of those tagged in Nantucket Sound was determined when the fish were recaptured and returned for measurements. The length frequencies, by sex, of these fish (at time of tagging) show that the females were larger than the males (Fig. 6). For both areas there was a length mode at about 40 cm for males and a less clear length mode at about 45 cm for females. There also appeared to be a secondary mode at about 45 cm for males from Block Island Sound.

DISCUSSION

From the 1,833 summer flounder tagged on offshore grounds in the Block Canyon area in March 1961 there were 155 recaptures, 8.4% of the total released. Recaptures were reported through August 1963, or 30 mo following tagging. From the

Figure 9.—Tagged summer flounder release positions for September 1962 releases (open squares) and 1962 recapture locations in September (circles) and October-December (triangles).

Figure 10.—Tagged summer flounder release positions for September 1962 releases (open squares) and 1963 recapture locations in January-March (circles) and April-June (triangles).

Figure 11.—Tagged summer flounder release positions for September 1962 releases (open square) and 1963 recapture locations in July-September (circles) and October-December (triangles).

Figure 12.—Tagged summer flounder release positions for September 1962 releases (open squares) and 1964 recapture locations in January-March (circles) and April-June (triangles).

Figure 13.—Tagged summer flounder release positions for September 1962 releases (open squares) and 1964 recapture locations in July-September (circles) and October-December (triangles).

Table 2.—Recoveries of tagged summer flounder from 1962 inshore releases by season and fisherman type, September 1962-January 1968.

Period of recovery	Number of recoveries by fisherman type			
	Commercial	Recreational	Unknown	Total
1962				
September	34	1	1	36
October-December	25	—	—	25
1963				
January-March	110	—	—	110
April-June	57	2	—	59
July-September	79	8	1	88
October-December	9	—	2	11
1964				
January-March	36	—	—	36
April-June	26	1	2	29
July-September	18	1	—	19
October-December	2	—	—	2
[1]1965-68				
January-March	11	—	—	11
April-June	7	2	—	9
July-September	9	1	—	10
October-December	1	—	—	1
All months	424	16	6	446
Percentage	95.1	3.6	1.3	100.0

[1]There were 33 total recaptures for this period; however, month of recapture was available for only 32 of these.

1,006 fish tagged on inshore grounds of Block Island and Nantucket Sounds in September 1962 there were 448 recaptures, 44.5% of the total released, obtained over a period of 65 mo following tagging. The difference in number recaptured in the two groups and the timespan over which they were recaught is large, considering that both were exposed to approximately similar fishing efforts. We attribute this difference primarily to a greater tagging mortality in the offshore releases, which were from depths of about 90 m and were in less vigorous condition than those tagged inshore, which were from 27 m or less. While the flounders have no gas bladders to cause decompression injury, they may have been hurt by the rapid pressure drop as they were brought from deep water to the surface. Tow length may also have been a factor. The fish tagged offshore were caught in tows of 45-60 min duration and therefore may have suffered greater injury in the trawl than those on inshore grounds, which were mostly caught in tows of 30 min. In addition, tows on the offshore grounds frequently contained some spiny dogfish, *Squalus acanthias,* whose rough skin and spines abrade other fishes in the trawl.

There was evidence of some tagging mortality among inshore releases, also, based on the tag return rate of newly tagged summer flounder that were recaught during later tagging tows and re-released. In the Block Island Sound tagging, 23 of the tagged fish recaught during tagging tows were re-released in apparently good condition. Of these only four subsequently were recaptured, for a total tag return rate of 17.4%. This is much lower than the 50% return rate for the Block Island Sound releases as a whole. In addition to this, two of the Block Island Sound releases, which never previously had been recaught, were picked up dead and decomposed a few days after tagging in the trawl of the commercial vessel that had been used during tagging.

In the course of the Nantucket Sound tagging, 90 of the tagged fish were recaught in later tagging tows and re-released. Of these, 10 subsequently were recaptured, a total return rate of 11.1%. Again, this was much lower than the 40.8% return rate for Nantucket Sound releases as a whole.

It seems clear from the above that a significant number of the summer flounder from inshore releases died from the catching and tagging operations. This mortality needs to be considered in estimating population parameters from the tag return data.

The summer flounder tagged in April 1961 on offshore grounds (Fig. 1) moved during the spring and summer northwest, north, and northeast to coastal areas; there was no movement to the south of the Sandy Hook, N.J., area (Figs. 3-5). During the fall the movement was back toward the offshore winter grounds near the outer shelf edge; in the winter all of the recaptures were from the offshore grounds with many of them coming from the vicinity of tagging. Some of the offshore returns, however, were from areas up to about 220 km to the east of the release point, indicating that there also was some eastward movement of summer flounder on offshore grounds (Fig. 5). None of the returns were from areas east of Veatch Canyon and, insofar as is known, this is the eastern limit for movement of this species in any numbers, although they occasionally are caught on Georges Bank (Bigelow and Schroeder 1953).

Few of the tag recoveries were from offshore areas southwest of the point of tagging, suggesting that there was little movement in that direction (Fig. 5). This apparently was not a result of lack of fishing effort, since New Jersey vessels regularly fish offshore grounds south of Hudson Canyon in the winter (Widerstrom 1959); if any numbers of tagged summer flounder had moved there, it is likely that more would have been caught.

The general pattern of recoveries from these offshore releases indicated that the summer flounder that move as far north as the winter grounds north of Hudson Canyon become rather permanent residents of the northern part of the Middle Atlantic Bight.

The summer flounder tagged in September 1962 on inshore areas of Block Island and Nantucket Sounds (Fig. 1) moved in the fall and early winter to offshore winter grounds from the vicinity of Veatch Canyon on the east to as far south as Baltimore Canyon (Figs. 9-13). Some of the recaptures from these releases clearly had moved farther south on the offshore grounds than did those from the 1961 offshore releases. There appears to be no clear explanation for this difference, although variations in the winter bottom temperature on offshore grounds may have altered summer flounder distribution, as was suggested by Nesbit and Neville (1935).

The large cluster of winter returns from the vicinity of Block Canyon (Fig. 10) may be regarded, at least in part, as a function of fishing effort in this intensively fished area. However, the area also is a productive winter fishing ground for squid (Lux et al. 1974), an important summer flounder food. It is possible, therefore, that summer flounder aggregate there to some extent for feeding.

Tag recoveries during the spring and summer of 1963 and 1964 from the inshore releases (Figs. 10-13) show that the fish in these seasons moved back inshore to areas from Long Island to south of Cape Cod. Many were recaught at points of release. The general tendency was for these returns to be made from areas farther to the east as the summer progressed. There were very few spring and summer returns from inshore areas south of Long Island, further indicating that fish that had moved to New England waters did not move far to the south in subsequent years.

The results from the 1961 and 1962 tagging studies showed movement patterns similar to those found for fish tagged in inshore waters of New York and New Jersey (Westman and Neville 1946; Poole 1962; Murawski footnote 3). The New York and New Jersey summer flounder, however, moved farther

south in the winter months and generally did not move as far north in the summer as the New England releases did. In all of these more southern studies, there was a trend towards fish movement to the northeast with the passage of time. All of this coincides with the general view that the major nursery grounds for this species are in estuaries and bays from Virginia to North Carolina and that many of the fish tend to move northward as they grow older (Poole 1966).

To provide more information on this apparent northward dispersal with age, Murawski (footnote 3), studying movements of tagged summer flounder in New Jersey coastal waters, compared the lengths of fish recaptured from north and south of the release areas to see if there was a difference in fish size with direction of movement. He found no consistent differences for those releases. As we mentioned here earlier, some of the recaptures from our 1962 inshore releases were recaught in 1963 and 1964 on winter grounds far south of the release areas (Figs. 10, 12). To examine the possibility that there might be a north-south size difference in these offshore recaptures, we calculated the mean lengths, at tagging, for fish that were recaptured in January-March 1963 and 1964 north of lat. 39°N and those caught south of this latitude. The results of this (Table 3) suggest that the recaptures north of lat. 39°N were about 2 cm longer. The small numbers of fish involved in these samples, however, make it difficult to settle this question.

Table 3.—Numbers of tag recaptures north and south of lat. 39°N in January-March 1963 and 1964 from 1962 inshore releases, and mean lengths and length ranges, in centimeters, at time of tagging.

	Area	Number of recaptures	Mean Length	Length range
1963	North of lat. 39°N	84	45.4	36-60
1963	South of lat. 39°N	22	42.8	38-50
1964	North of lat. 39°N	20	44.6	40-52
1964	South of lat. 39°N	8	42.6	40-45

Most of the tag recaptures of our study were made during the January-April offshore fishery and during the inshore season from June-September (Tables 1, 2). A large proportion of recaptures in any one year was in the January-March quarter. In all cases these were caught by the commercial fleet since summer flounder is not available to anglers in winter. Landing statistics show that this quarter usually is the time of greatest commercial catches of summer flounder for New England trawlers.

Few tag recoveries were obtained in October-December, indicating that the fishing pressure on this species was low then. This probably was related to the dispersed nature of the summer flounder population during the fall migration to offshore areas. An advantage of a low fishing mortality at this time is that the fish are relatively undisturbed during spawning, which occurs during their offshore movement to winter grounds (Smith 1973).

Who recaptures the tagged summer flounder depends largely upon when and where the fish are tagged. Recreational fishermen recovered 26.5% of our April 1961 offshore releases and only 3.6% of those in the September 1962 inshore series. Most of the angler recaptures from the 1961 tagging were from Long Island bays, which are areas of great sport fishing activity. Angler returns from the 1962 releases, on the other hand, were mostly from New England waters, where the angler population is smaller.

Recreational fishermen caught a large proportion of tagged summer flounder released in past studies on inshore New York and New Jersey grounds, in contrast to the results from the inshore New England releases. In tagging studies in Great South Bay, Long Island, for example, up to about 60% of summer flounder recaptures were made by anglers (Westman and Neville 1946; Poole 1962); in tagging off New Jersey, sport fishermen caught up to 60% of the summer flounder released near Sandy Hook and up to 49% of those tagged off Cape May (Murawski footnote 3).

Although no age studies have been done in conjunction with the tagging, some inferences about age composition and growth rate of summer flounder can be drawn from the size compositions, by sex, of the recaptured fish (Fig. 6). In the fish tagged offshore in April 1961, about the time when growth starts for the year, the male modal length is about 35 cm, which is close to the length calculated from otoliths of 345 mm at age 3 given by Smith and Daiber (1977); likewise, the mode for females at about 40 cm is close to their calculated length at age 3 of 380 mm. For the fish that we tagged in September 1962 in Block Island and Nantucket Sounds (Fig. 6), there are modes for males at about 40 cm, which correspond closely with the 397 mm calculated length at age 4 of Smith and Daiber. While no clear modes appear in the size frequencies of females in the 1962 samples, there is some evidence of modes at about 45 cm. This value, also, is close to the 453 mm length calculated at age 4 by Smith and Daiber. Fish measured in September can be expected to have completed most of their growth for that calendar year, and their lengths generally would differ little from those at the time of formation of their next annulus.

As indicated earlier, small flounder, less than about 28 cm in length, are uncommon off New England. Coupled with this fact, the size distributions of Figure 6 suggest that most summer flounder do not arrive in New England waters until they have reached age 3, although it seems likely that some of the faster growing 2-yr-olds also make this migration.

The reason for describing the size and age composition in some detail here is its potential value in measuring summer flounder recruitment. If modes in size frequencies taken in New England can be identified with age group 3, then it should be possible to get an estimate of recruitment of 3-group fish to the New England area by obtaining length frequencies by sex of summer flounder from limited special otter trawl surveys for this species. From the data of Figure 6 and from information on the pattern of seasonal distribution, a good time of year to attempt such a survey would be in the late spring, when the fish have arrived on inshore New England grounds such as Block Island, Vineyard, and Nantucket Sounds.

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